CLAIMS

WHAT IS CLAIMED IS:

1. A conductive composition for modification of charge transport across a nanostructure-containing matrix, the composition comprising:

a body structure comprising a conjugated organic moiety;

a head group coupled to the body structure at a first position on the conjugated organic moiety, wherein the head group comprises a functionalized head group capable of binding to a nanostructure surface or a head group bound to a nanostructure surface; and

a tail group coupled to the body structure at a second position on the conjugated organic moiety;

wherein one or more elements of the conductive composition are capable of removing or adding charges to a nanostructure upon attachment to a surface of the nanostructure, thereby modifying charge transport across a nanostructure-containing matrix.

2. The composition of claim 1, wherein the nanostructure is a nanocrystal.

3. The composition of claim 1, wherein the nanostructure is an inorganic nanocrystal.

4. The composition of claim 1, wherein the functionalized head group comprises one or more phosphonic acid, carboxylic acid, amine, phosphine, or thiol moieties.

5. The composition of claim 1, wherein the functionalized head group or bound head group comprises a monodentate structure.

6. The composition of claim 1, wherein the functionalized head group or bound head group comprises a multidentate structure.

7. The composition of claim 1, wherein the body structure comprises a conjugated alkyl moiety or a conjugated aryl moiety.

8. The composition of claim 7, wherein the body structure comprises a phenylene, thiophene, ethene, ethyne, aniline, fluorene, pyridine, perylene, phenanthralene, anthracene, alkenyl or polynuclear aromatic moiety.

9. The composition of claim 1, wherein the body structure further comprises one or more O-linked or N-linked sidechain coupled to the conjugated organic moiety.

10. The composition of claim 9, wherein the sidechain comprises an electron donating group.

11. The composition of claim 9, wherein the sidechain comprises an electron withdrawing group.

12. The composition of claim 9, wherein the sidechain comprises a conducting chemical structure, whereby the one or more sidechain extends the conjugation of the body structure.

13. The composition of claim 9, wherein the sidechain comprises a polymerizable element.

14. The composition of claim 13, wherein the polymerizable element comprises an acrylate moiety, a methacrylate moiety, or a vinyl moiety.

15. The composition of claim 9, wherein a first sidechain is coupled to the body structure at a first sidechain position, and wherein a second sidechain is coupled to the body structure at a second sidechain position.

16. The composition of claim 15, wherein the first and second sidechains are different chemical moieties.

17. The composition of claim 15, wherein the first and second sidechains are identical chemical moieties.

18. The composition of claim 9, wherein the sidechain alters a solubility of the composition.

19. The composition of claim 9, wherein the sidechain is matched functionally and/or electronically to a matrix composition of the nanostructure-containing matrix.

20. The composition of claim 9, wherein the sidechain comprises an O-linked hexane moiety, an O-linked 2-ethylhexyl moiety, an O-linked octyl moiety, an O-linked decyl moiety, or an O-linked alkyl moiety comprising between 5 and 22 carbons.

21. The composition of claim 9, wherein the sidechain comprises an N-linked hexane moiety, an N-linked 2-ethylhexyl moiety, an N-linked octyl moiety, an N-linked decyl moiety, or an N-linked alkyl moiety comprising between 5 and 22 carbons.

22. The composition of claim 9, wherein the sidechain comprises a chemical substituent having greater than 22 carbons.

23. The composition of claim 9, wherein the one or more sidechain and the tail group comprise identical chemical compositions.

24. The composition of claim 1, wherein the body structure comprises an oligomeric or polymeric structure.

25. The composition of claim 24, wherein the body structure comprises a poly(phenylene), poly(thiophene), poly(ethene), poly(ethyne), poly(aniline), poly(fluorene), poly(pyridine), or a poly(polynuclear aromatic) moiety.

26. The composition of claim 24, wherein the body structure further comprises one or more sidechain coupled to one or more elements of the oligomeric or polymeric structure.

27. The composition of claim 1, wherein the tail group comprises a conducting chemical structure.

28. The composition of claim 1, wherein the tail group comprises a nonconducting chemical structure.

29. The composition of claim 1, wherein the tail group comprises an alkene or an alkyne moiety.

30. The composition of claim 1, wherein the tail group comprises 1-propyne, 1-butyne, 1-pentyne, 1-hexyne, 1-heptyne, 1-octyne, 1-nonyne, 1-decyne, or an alkyne comprising between 3 and 22 carbons.

31. The composition of claim 1, wherein the tail group comprises an alkyne comprising more than 22 carbons.

32. The composition of claim 30, wherein the tail group further comprises a thiophene moiety positioned between the body structure and an alkyne moiety.

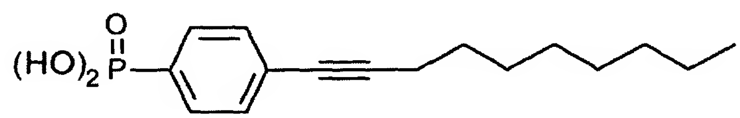
33. The composition of claim 1, wherein the tail group comprises a chemical functionality capable of binding to the nanostructure surface or an additional nanostructure surface.

34. The composition of claim 1, wherein the tail group comprises a monodentate structure.

35. The composition of claim 1, wherein the tail group comprises a multidentate structure.

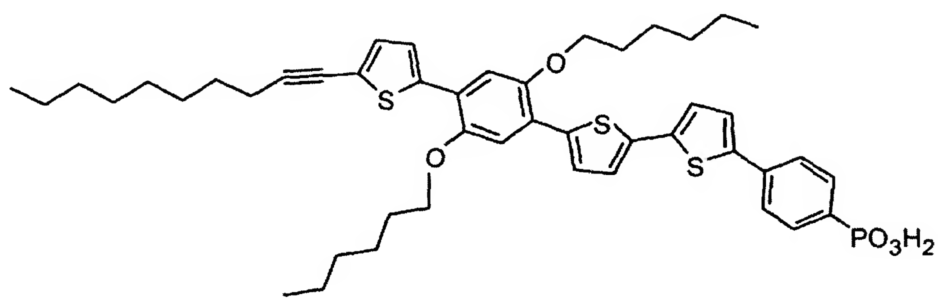
36. The composition of claim 1, wherein the tail group comprises a polymerizable element.

37. A conductive composition for modification of charge transport across a nanostructure-containing matrix, the composition having the formula:



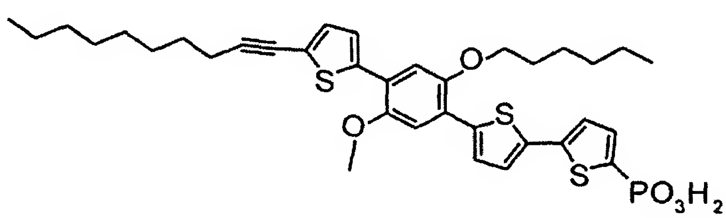
38. The conductive composition of claim 37, wherein the nanostructure is a nanocrystal.

39. A conductive composition for modification of charge transport across a nanostructure-containing matrix, the composition having the formula:



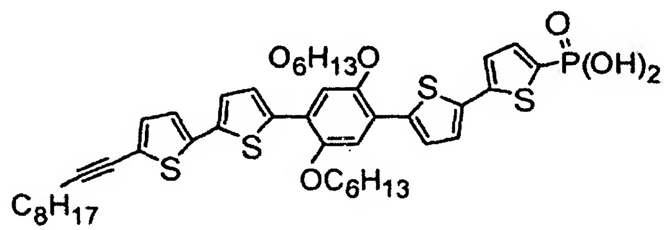
40. The conductive composition of claim 39, wherein the nanostructure is a nanocrystal.

41. A conductive composition for modification of charge transport across a nanostructure-containing matrix, the composition having the formula:



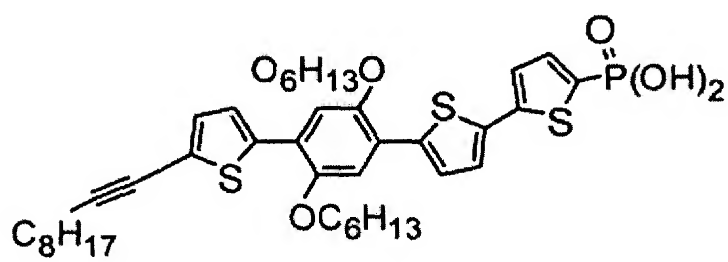
42. The conductive composition of claim 41, wherein the nanostructure is a nanocrystal.

43. A conductive composition for modification of charge transport across a nanostructure-containing matrix, the composition having the formula:



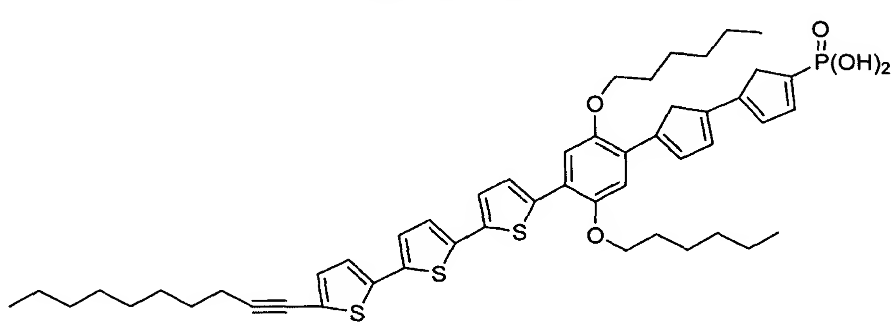
44. The conductive composition of claim 43, wherein the nanostructure is a nanocrystal.

45. A conductive composition for modification of charge transport across a nanocrystal-containing matrix, the composition having the formula:



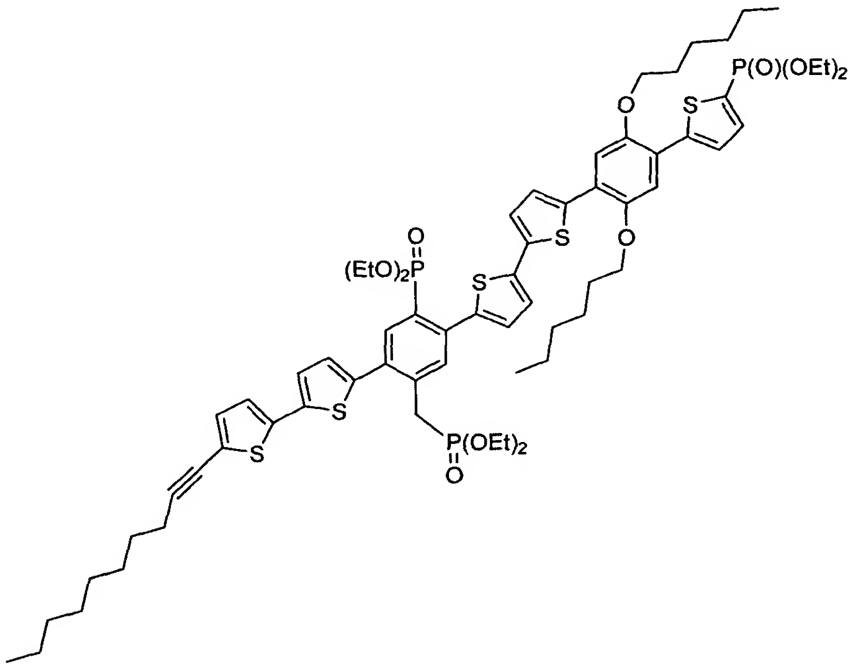
46. The conductive composition of claim 45, wherein the nanostructure is a nanocrystal.

47. A conductive composition for modification of charge transport across a nanostructure-containing matrix, the composition having the formula:



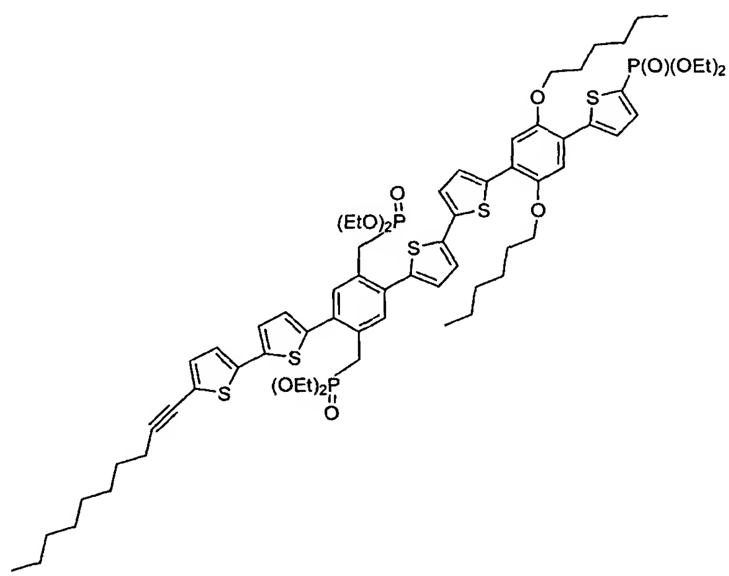
48. The conductive composition of claim 43, wherein the nanostructure is a nanocrystal.

49. A conductive composition for modification of charge transport across a nanostructure-containing matrix, the composition having the formula:



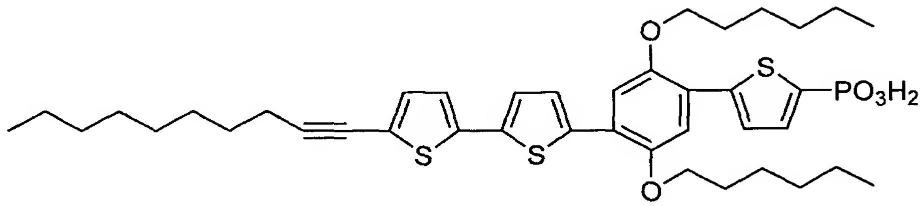
50. The conductive composition of claim 43, wherein the nanostructure is a nanocrystal.

51. A conductive composition for modification of charge transport across a nanostructure-containing matrix, the composition having the formula:



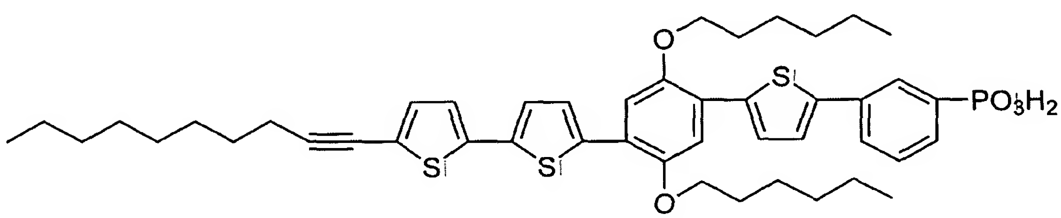
52. The conductive composition of claim 43, wherein the nanostructure is a nanocrystal.

53. A conductive composition for modification of charge transport across a nanostructure-containing matrix, the composition having the formula:



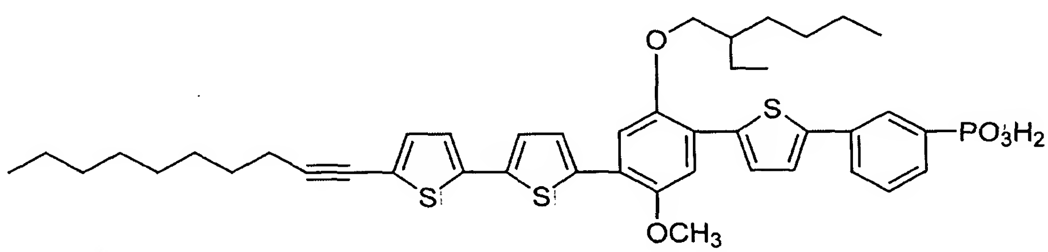
54. The conductive composition of claim 43, wherein the nanostructure is a nanocrystal.

55. A conductive composition for modification of charge transport across a nanostructure-containing matrix, the composition having the formula:



56. The conductive composition of claim 43, wherein the nanostructure is a nanocrystal.

57. A conductive composition for modification of charge transport across a nanostructure-containing matrix, the composition having the formula:



58. The conductive composition of claim 43, wherein the nanostructure is a nanocrystal.

59. A polymeric conductive composition comprising the structure $[H_x\text{-}B_y\text{-}T_z]_n$,

wherein H comprises at least one functionalized head group capable of binding to a nanostructure surface or at least one head group bound to a nanostructure surface;

wherein B comprises a body structure comprising one or more conjugated organic moieties, wherein a first conjugated organic moiety is coupled to a proximal functionalized head group or bound head group;

wherein T comprises at least one tail group coupled to the body structure; and

wherein x, y, z and n independently comprise integers equal to or greater than 1 and wherein x+y+z+n is equal to or greater than 5.

60. The polymeric conductive composition of claim 59, wherein the head group comprises one or more phosphonic acid, carboxylic acid, amine, phosphine, or thiol moieties.

61. The polymeric conductive composition of claim 59, wherein the body structure comprises a phenylene, thiophene, ethene, ethyne, aniline, fluorene, pyridine, perylene, phenanthralene, anthracene, alkenyl or polynuclear aromatic moiety.

62. The polymeric conductive composition of claim 59, wherein the body structure comprises poly(phenylene), poly(thiophene), poly(ethene), poly(ethyne), poly(aniline), poly(fluorene), poly(pyridine) moiety, or poly(polynuclear aromatic) moiety.

63. The polymeric conductive composition of claim 59, wherein the tail group comprises 1-propyne, 1-butyne, 1-pentyne, 1-hexyne, 1-heptyne, 1-octyne, 1-nonyne, 1-decyne, or an alkyne comprising between 3 and 22 carbons.

64. The polymeric conductive composition of claim 59, wherein the body structure further comprises one or more O-linked or N-linked substituents coupled to one or more member conjugated organic moieties, wherein the substituents alter an electronic signature or a solubility of the polymeric conductive composition.

65. The polymeric conductive composition of claim 64, wherein the polymeric conductive composition is polymerized through polymerizable elements on the one or more substituents.

66. The polymeric conductive composition of claim 64, wherein the one or more substituents independently comprise an electron donating group, an electron withdrawing group, a conducting chemical structure, or a nonconducting chemical structure.

67. A nanostructure matrix composition comprising:

a nanostructure comprising an exterior surface, wherein a portion of the nanostructure exterior surface is bound to the conductive composition of claim 1; and,

a matrix positioned proximal to the conjugated exterior surface of the nanostructure.

68. The nanostructure matrix composition of claim 67, wherein the matrix comprises poly-3-hexylthiophene (P3HY).

69. The nanostructure matrix composition of claim 67, wherein the matrix is covalently coupled to the conductive composition of claim 1.

70. The nanostructure matrix composition of claim 67, wherein the conductive composition is functionally or electronically matched to one or more substituents of the matrix.

71. The nanostructure matrix composition of claim 67, wherein the nanostructure is a nanocrystal.

72. A nanostructure-containing matrix composition comprising:

a nanostructure comprising an exterior surface; and

a matrix composition positioned proximal to the exterior surface of the nanostructure, wherein the matrix composition comprises a conductive polymer having the structure $[T_x\text{-}B_y\text{-}H_z]_n$, wherein H comprises at least one functionalized head group capable of binding to a nanostructure surface; wherein B comprises a body structure comprising one or more conjugated organic moieties, wherein a first conjugated organic moiety is coupled to the at least one functionalized head group; wherein T comprises at least one tail group coupled to the body structure; and wherein x, y, z and n independently comprise integers equal to or greater than 1.

73. The nanostructure-containing matrix composition of claim 72, wherein a portion of the nanocrystal exterior surface is conjugated with the conductive composition of claim 1.

74. The nanostructure matrix composition of claim 73, wherein the matrix composition and the conductive composition are matched functionally and/or electronically.

75. The nanostructure matrix composition of claim 73, wherein the matrix composition and the conductive composition are covalently coupled.

76. The nanostructure matrix composition of claim 73, wherein the nanostructure is a nanocrystal.

77. A method of synthesizing an organic composition that facilitates charge transfer for use in a nanostructure-containing device, the method comprising:

a) providing a conjugated organic precursor, wherein the conjugated organic precursor comprises at least three positions available for attachment of substituent modules;
b) providing a first substituent module, wherein the first substituent module comprises a phosphonic acid derivative, a carboxylic acid derivative, an amine derivative, a phosphine derivative, a thiol derivative, a thiophene derivative, or a combination thereof;
c) providing a second substituent module, wherein the second substituent module comprises an alkyne derivative comprising between three and 22 carbons; and
d) optionally providing a third substituent module, wherein the optional third substituent module comprises an alkyl derivative comprising between one and 22 carbons;
e) coupling the first substituent module at a first position, coupling the second substituent module at a second position, and optionally coupling the third substituent module at a third position, thereby synthesizing the organic composition;

wherein coupling of the modules to the body structure does not destroy an electronic conjugation of the body structure, and,

wherein at least one substituent of the first, second or third substituent modules is capable of binding to a nanostructure surface or is already bound to a nanostructure surface.

78. The method of claim 77, wherein the conjugated organic precursor comprises a conjugated alkyl moiety or a conjugated aryl moiety.

79. The method of claim 78, wherein the conjugated organic precursor comprises a phenylene, thiophene, ethene, ethyne, aniline, fluorene, pyridine, perylene, phenanthralene, anthracene, alkenyl or polynuclear aromatic derivative.

80. The method of claim 78, wherein the conjugated organic precursor comprises a poly(phenylene), poly(thiophene), poly(ethene), poly(ethyne), poly(aniline), poly(fluorene), or poly(pyridine) derivative.

81. The method of claim 77, wherein coupling of one or more of the substituent modules to the body structure extends the conjugation of the body structure.

82. The method of claim 77, wherein the optional third substituent module is coupled to the conjugated organic precursor prior to coupling the first and/or second substituent modules.

83. The method of claim 77, wherein providing the first substituent module comprises providing a thiophene derivative.

84. The method of claim 83, wherein providing the first substituent module comprises:

a) providing an arylhalide core structure;
b) lithiating the arylhalide core structure at a first halide position and reacting with chlorotrimethylsilane (TMSCl) to yield a TMS-aryl intermediate core structure;
c) lithiating of the TMS-intermediate core structure at a second halide position and reacting with trimethyltinchloride (Me_3SnCl) to yield a stannylated second intermediate; and,
d) combining the second intermediate with a halogenated thiophene to form a first substituent module comprising a TMS-aryl-thiophene derivative.

85. The method of claim 83, wherein the first substituent module comprises an aryl-thiophene moiety and wherein coupling the first substituent module comprises:

a) performing a Stille coupling to form an iodinated intermediate;
b) exchanging an iodine substituent of the iodinated intermediate for a TMS substituent; and,
c) coupling a phosphite group to the aryl portion of the bound first substituent module via a palladium-catalyzed mechanism.

86. The method of claim 83, wherein the first substituent module comprises diethylphosphite, and wherein coupling the first substituent module comprises performing a palladium-catalyzed phosphite-aryl coupling.

87. The method of claim 77, wherein coupling the second substituent module comprises performing a Sonogashira coupling.

88. The method of claim 77, wherein the steps of providing the first substituent and/or providing the second substituent comprise generating thiophene derivatives of the first and/or second substituents.

89. The method of claim 77, wherein coupling the optional third substituent module comprises alkylating the conjugated organic precursor at third position comprising a hydroxyl or amine moiety, to form a sidechain-substituted intermediate composition.

90. The method of claim 77, wherein providing the third substituent module comprises providing about 1.1 molar equivalents of a halogenated derivative of a sidechain substituent; and wherein coupling the third substituent module with the conjugated organic precursor comprises:

i) combining the halogenated derivative with the conjugated organic precursor in the presence of potassium carbonate (K_2CO_3) and dimethyl formamide (DMF) to form a reaction mixture; and,

ii) heating the reaction mixture to about 70°C, thereby coupling the third substituent to the conjugated organic moiety.

91. The method of claim 77, wherein coupling the third substituent further comprises coupling a fourth substituent to the body structure at a fourth position.

92. The method of claim 91, wherein the third substituent and the fourth substituent comprises different chemical species.

93. The method of claim 91, wherein the third substituent and the fourth substituent comprises identical chemical species, and wherein the steps of coupling the first substituent and coupling the fourth substituent are performed in a single reaction mixture.

94. The method of claim 77, further comprising:

f) coupling the head group to an external surface of a nanocrystal, thereby providing a nanocrystal-bound composition.

95. The method of claim 94, wherein the nanostructure comprises CdTe or InP.

96. The method of claim 94, wherein coupling the head group to the external surface of the nanostructure comprises interacting one or more free electrons in the head group with proximal metal moieties of the nanostructure.

97. The method of claim 94, further comprising:

g) polymerizing the organic composition after coupling the composition to the nanocrystal surface, thereby forming a polymerized organic composition.

98. The method of claim 77, wherein the nanostructure-containing device comprises a photovoltaic device.

99. A method of modifying an interaction between a nanostructure and an external matrix, the method comprising:

treating a nanostructure with the conductive composition of claim 1; and,

forming a nanostructure-containing matrix comprising the treated nanostructure and a matrix composition.

100. The method of claim 99, wherein treating the nanostructure further comprises polymerizing the conductive composition of claim 1 to form a polymerized conductive composition.

101. The method of claim 99, wherein the matrix composition comprises the polymeric conductive composition of claim 59.

102. The method of claim 99, wherein the nanostructure is a nanocrystal.

103. A device comprising:

a) a first electrode surface;
b) the nanostructure matrix composition of claim 67 electrically coupled to the first electrode surface; and,
c) a second electrode surface electrically coupled to the nanostructure -containing matrix composition.

104. The device of claim 103, wherein the nanostructure matrix composition comprises one or more nanocrystals.

105. A device comprising:

d) a first electrode surface;
e) the nanostructure-containing matrix composition of claim 72 electrically coupled to the first electrode surface; and,
f) a second electrode surface electrically coupled to the nanostructure -containing matrix composition.

106. The device of claim 105, wherein the nanostructure-containing matrix composition comprises one or more nanocrystals.